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DYNAMIC SPECTRUM ACCESS TECHNIQUE USING MARKOV CHAIN

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ABSTRACT

Dynamic Spectrum Access (DSA) is the new paradigm to access the unused spectrum at a given time. When designated user arrived on its licensed spectrum, a user will be hopped to the new vacant spectrum band in the white space. A Markov Chain (MC)is a stochastic model describing a sequence of possible events in which the probability of each event depends only on the state attained in the previous event.

In this paper, we considered the dynamic spectrum access as a Markov Chain. We correlated DSA and MC and analyzed MCs. We create two MCs using a matrix of observed transition count and convert it with transition probability matrix. Then we plotted the Eigen values of transition matrices on the complex plane. Also, we find the stationary distribution of MCs. This analysis helps us to determine the channel's behavior and help us to prioritize the channels for the better quality of access.

KEYWORDS: Cognitive Radio, Dynamic Spectrum Access & Markov Process

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Original Article

INTRODUCTION

Wireless technology is developing rapidly and offering many societal and individual benefits. The output of this technology is more penetrative because of its application in consumer devices such as cell phone, laptops, and PDAs. The explosion of wireless applications created an ever-increasing demand for more radio spectrum. The spectrum is fixed and therefore only technology can help to bridge the gap to meet these demands.

Dynamic spectrum access (DSA) is a new spectrum sharing paradigm that utilizes the spectrum holes and hence increases spectrum utilization as well as alleviates the spectrum scarcity problem.

Underutilized VHF/UHF frequency bands in TV space are the best suitable band because of low-loss propagation properties which allow the long-reach and non-line-of-sight (LOS) communication

Like electricity a century ago, broadband is a foundation for economic growth and a better way of life. It is unlocking vast new possibilities for existing ones and enabling entire new industries. It is changing how we manage energy, deliver health care, educate children, ensure public safety, engage government etc.

The precise definition of MC [4] varies, for example, it is common to define the Markov chain as a Markov process in either discrete or continuous time with a countable state space. It is also common to define it as having discrete time in either countable or continuous state space.

In this paper, we correlate the DSA and MC. We analyzed the MC and results re-applicable to DSA.

The rest of the paper is organized as follows. In section II the concept of CR and DSA is briefly explained. In section III the wireless Regional Area Network (WRAN) standard IEEE 802.22 is elaborated in which the DSA techniques are applied. In section IV the two MCs are generated and their performances are compared. The section V is the conclusion.

COGNITIVE RADIO (CR) AND DYNAMIC SPECTRUM ACCESS (DSA)

Cognitive Radio

Cognitive radio [1] offers the promise of being innovative that will enable future wireless works. Cognitive radios are fully programmable wireless devices that can sense their environment and dynamically adapt their channel access method, transmission waveform, spectrum use, and networking protocols.

Cognitive radio networks (CRNs) that are self-organizing and adaptive radio networks that are capable of responding to environmental changes.

CRNs with some extra capabilities such as dynamic spectrum access (DSA) have the potential for dramatically improving spectrum efficiency. Cognitive radios are fully programmable wireless devices that can sense their environment and dynamically adapt their transmission waveform, spectrum use, channel access method and networking protocols as needed for good network and application performance.

This cognitive radio is useful where we need radios that can operate in multiple frequency bands. Most radios used today were designed for a particular band. This cognitive radio is also useful where we need radios that can decide which frequency band to use since it is in most cases unrealistic that the user will be able to pick the right band.

Specifically, the wireless devices will need to agree on how to realize various physical, link and network layer functions in a way that makes the best use of the available spectrum, while satisfying the policy constraints that apply in the selected band as well.

Cognitive Radio Networks (CRNs) are the perfect network which realizes the above functionality.

Dynamic Spectrum Access

With DSA [2], secondary users dynamically search for idle spectrum bands and temporarily access them for wireless communications. Secondary users continuously monitor the spectrum bands to avoid the interference to primary users (PUs), whenever primary users start using a band, secondary user dynamically accesses another vacant band using cognitive capabilities of radio.

DSA is made possible by advances in CR technology. Most radio functions are implemented through software running on the digital processors, through programming the digital processors, a cognitive radio can sense the surrounding spectrum environment and accordingly adapt radio parameters such as bandwidth, transmit power, center frequency, and waveform to utilize spectrum bands currently not used by PUs.

IEEE 802.22 WRAN (WIRELESS REGIONAL AREA NETWORK)

Introduction

The IEEE standard for cognitive wireless regional area network IEEE 802.22 [3] is the first cognitive standard release. The most prominent target application of 802.22 is wireless broadband access in remote and rural areas.

Regulatory bodies in each country are usually responsible for allocating the frequency bands for different services. In United States (US) it is FCC (federal communication commission), OFCOM in UK and CEPT in Europe. FCC has approved the cognitive concept and permits the secondary user to use TV white space. IEEE 802.22 WRANs are designed to operate in the TV broadcast bands while ensuring that no harmful interference is caused to the incumbent operation (i. e. digital TV and analog TV broadcasting) and low-power licensed devices such as wireless microphones.

System Architecture

The IEEE 802.00 WRAN standard provides wireless broadband access to a rural area of typically 17-30 km or more in a radius up to the maximum 100 km from the base station (BS). It serves up to 255 fixed units of customer premises equipment (CPE) with outdoor directional antennas located at 10 meters above ground level, similar to a typical VHF/UHF TV receiving installation. Due to the extended coverage, the physical layer (PHY) parameter must be optimized to absorb longer multi-path delays. Delay of up to 37µs can be absorbed by the orthogonal frequency division multiplexing (OFDM) modulation used in this standard.

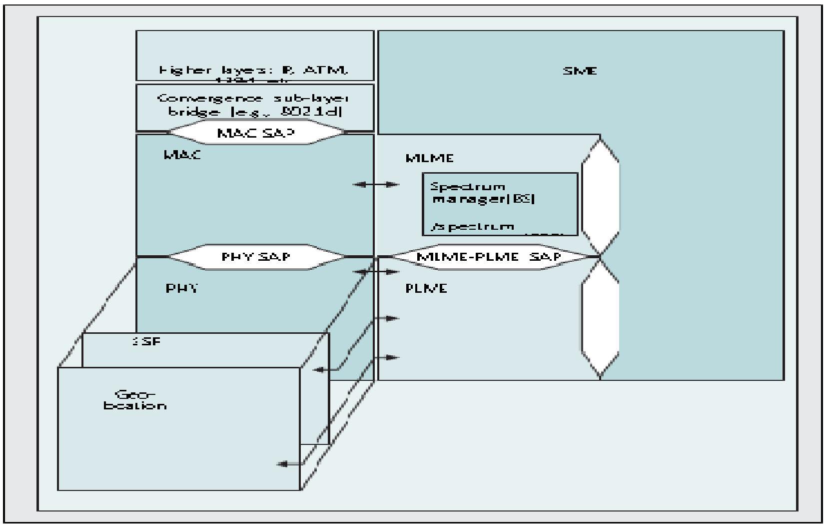

Figure 1: Reference Architecture for IEEE 802.22 System

MARKOV CHAIN ANALYSIS OF DSA

In this work, we consider the Markov chain state as a state of the channels. State 1 indicates the channel is free. State 2 states that the primary user is using the channel. State 3 indicates the secondary user's presence on the channels and state 4 indicate that secondary user using the channel but the primary user also arrived so that both are on the channel. It is shown in figure (2). We create the two MCs using transition probability matrix. Figure 3 and Figure 4 shows the eigen values of Markov chain 1 (MC1) and Markov chain 2 (MC2) on complex planes. Figure 5, showing the comparison of the stationary distribution of MC1 and MC2.

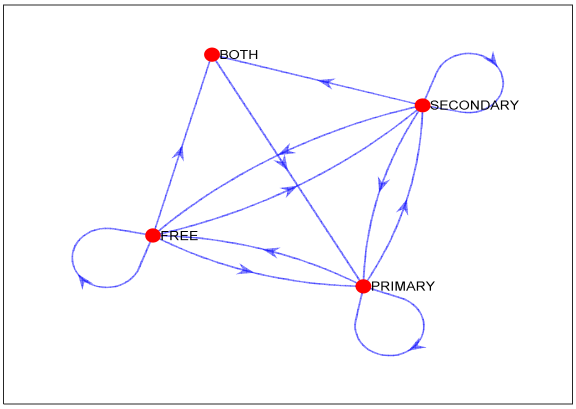

Figure 2: Markov Chain

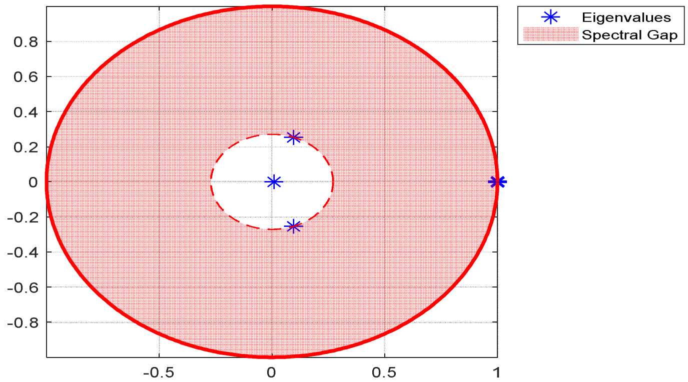

Figure 3: Eigen Values of MC1 on Complex Planes

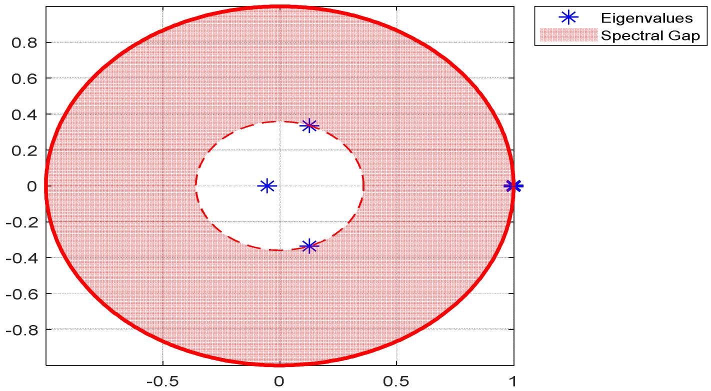

Figure 4: Eigen Values of MC2 on Complex Planes

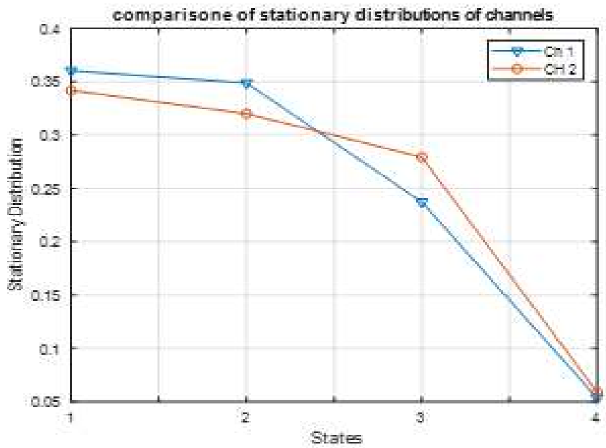

Figure 5: Stationary Distributions of Two MCs

CONCLUSIONS

- Eigen values are instrumental to understand the system. It tells us about systems that evolve step by step. Figure 3 and Figure 4 shows the Eigenvalues associated with MC1 and MC2 respectively. Also, it shows the spectral gap associated with these eigen values. This spectrum determines the structural properties of MC such as periodicity.
- A stationary distribution of an MC is a probability distribution that remains unchanged in an MC as it progresses. Stationary distribution of MC gives us the important confirmations like transient state and recurrent stat. Transient state indicates the state never reached and recurrent states form the groups and do not communicate with each other. The stationary distribution represents the limiting time-independent distribution of the state for Markov process as the number of steps on transition increases.
- Figure 5 shows that by increasing the transient probability of state 3 of MC2 the effect on stationary distribution. Such an analysis of the channels under DSA helps us to use the channels comparatively and effectively in the system.
- Figure 3 represents the MC1 having equal transition probability of state 2 and states 3 from state 1. Figure 4 represent the MC2 having unbalanced transition probability (0.15and 0.35) of state 2 and state 3 from state 1. It shows the wider spectral gap of MC1.

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